

signals to produce a correlation result that is integrated over the data-bit duration and over all tones.

GHM uses binary phase offsets instead of differential phase offsets. Thus, GHM does not provide carriers with phase relationships that enable the superposition of the carriers to have narrow time-domain signatures. Consequently, received GHM signals require processing by a correlator, whereas signals that are orthogonal in time can be processed using simpler signal-processing techniques, such as time sampling and weight-and-sum. Furthermore, GHM does not achieve the capacity and signal-quality benefits enabled by time-orthogonal signals.

U.S. Pat. No. 4,628,517 shows a radio system that modulates an information signal onto multiple carrier frequencies. Received carriers are each converted to the same intermediate frequency using a bank of conversion oscillators. The received signals are then summed to achieve the benefits of frequency diversity. In this case, frequency diversity is achieved at the expense of reduced bandwidth efficiency. The process of converting the received signals to the same frequency does not allow orthogonality between multiple information signals modulated on the same carriers. —”

CLAIMS

Please cancel claims 1 to 43 and substitute new claims 44 to 94 as follows:

I claim:

44. A method of transmitting a Carrier Interference Multiple Access (CIMA) communication signal comprising generating (14n) a plurality of electromagnetic carrier signals having a plurality of frequencies and modulating (12) the carrier signals with at least one information signal, the method characterized by:
- phase offsetting (16n) each of the plurality of carrier signals wherein the phase offsets are incremental phase offsets, and
 - combining (24) the modulated, phase-offset carrier signals into at least one communication channel to generate interference between the modulated, phase-offset carrier signals for providing at least one transmitted CIMA signal having a plurality of multi-frequency carrier-signal components.
45. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of generating (14n) a plurality of electromagnetic carrier signals includes generating a

plurality of groups of carriers having identical sets of carrier frequencies, each group being assigned to one of a plurality of users, and the step of phase offsetting (16n) the carriers includes providing a unique relative phase to the carriers of each group to provide each group having a unique time offset.

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46. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of generating (14n) a plurality of electromagnetic carrier signals includes generating a plurality of groups of carriers, each group having a unique set of carrier frequencies and being assigned to at least one user, and the step of phase offsetting (16n) the carriers includes providing a relative phase to each group such that each of a plurality of users may receive constructive superpositions of signals in the same time interval.
47. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of generating (14n) a plurality of electromagnetic carrier signals is characterized by a step of providing variations to the carrier frequencies with respect to time wherein the frequency variations for each carrier in a group of carriers corresponding to each user are substantially identical.
48. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of modulating (12) the carrier signals comprises a pulse-amplitude modulation being applied to a plurality of the carriers, the pulse-amplitude modulation having a duration that is longer than a constructive-interference signal resulting from a superposition of the carriers, and the step of combining (24) the modulated, phase-offset carrier signals into at least one communication channel being characterized by generating an interference signal between the modulated, phase-offset carrier signals having a duration that is longer than the constructive-interference signal.
49. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of modulating (12) the carrier signals comprises a pulse-amplitude modulation being applied to a plurality of the carriers, the pulse-amplitude modulation having a duration that is shorter than a constructive-interference signal resulting from a superposition of the carriers, and the step of combining (24) the modulated, phase-offset carrier signals into at least one communication channel being characterized by generating an interference signal between the

modulated, phase-offset carrier signals having a duration that is shorter than the constructive-interference signal.

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50. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of modulating (12) the carrier signals is performed in at least one predetermined time interval relative to the phase of the carriers, and the step of combining (24) the modulated, phase-offset carrier signals being characterized by generating a signal having modulated carrier-signal components that occupy at least one nonzero-phase space and combine destructively in zero-phase space.
51. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of generating (14n) a plurality of electromagnetic carrier signals being characterized by a step of tapering a frequency-versus-amplitude window of the carrier signals, and the step of combining (24) the modulated, phase-offset carrier signals being characterized by producing a transmitted CIMA signal having reduced time-domain side-lobe energy.
52. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of combining (24) the modulated, phase-offset carrier signals includes coupling the carrier signals into at least one of a set of communication channels including a waveguide and a free-space channel.
53. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of phase offsetting (16n) the carriers is performed to match relative phases between the carriers to a dispersion profile of the carriers in a waveguide such that the dispersion causes the carrier phases to have a predetermined phase relationship after propagating a predetermined distance in the waveguide.
54. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of combining (24) the modulated, phased carrier signals is characterized by coupling the carrier signals from an array of transmitter elements into the channel.
55. The method of transmitting a CIMA communication signal recited in claim 54 wherein each carrier signal associated with a particular user is transmitted from a different transmitter

element, resulting in an array beam pattern being generated from a superposition of carrier signals transmitted by each of the transmitter elements.

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56. The method of transmitting a CIMA communication signal recited in claim 54 wherein a separation between the transmitter elements is selected with respect to carrier-frequency separation to control the shape of the array beam pattern and the period in which the array beam pattern scans.
 57. The method of transmitting a CIMA communication signal recited in claim 44 wherein the steps of modulating (12) and phase offsetting (16n) the carriers results in a train of pulses in the time domain modulated with a spread-spectrum code.
 58. The method of transmitting a CIMA communication signal recited in claim 57 wherein the spread-spectrum code comprises an information signal and a pseudo-random CDMA spreading code.
 59. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of phase offsetting (16n) produces at least two received constructive-interference pulses that overlap in time.
 60. The method of transmitting a CIMA communication signal recited in claim 44 wherein the step of phase offsetting (16n) includes a decision step (66) that allows for at least two received constructive-interference pulses to overlap in time when the number of users or channel usage increases beyond a predetermined limit.
 61. The method of communication recited in claim 60 wherein the decision step (66) includes a step of identifying the users and assigning a priority to each user that is used to determine which user signals overlap in time.
 62. In a method of receiving Carrier Interference Multiple Access (CIMA) communication signals comprising receiving (52) at least one transmitted CIMA signal from at least one communication channel to produce a plurality of received multi-frequency carrier-signal components, the improvement comprising:

combining (62m) the multi-frequency carrier-signal components in phase to generate at least one constructive-interference signal indicative of at least one information signal.

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63. The method of receiving CIMA communication signals recited in claim 62 wherein the step of combining (62m) the multi-frequency carrier-signal components includes providing (60mn) at least one set of predetermined delays to each set of received carrier-signal components wherein the number of sets of predetermined delays is equal to a number of different phase spaces in which the received CIMA transmit signal is combined.
64. The method of receiving CIMA communication signals recited in claim 62 wherein the step of combining (62m) the multi-frequency carrier-signal components includes providing (60mn) at least one set of predetermined delays to each set of received carrier-signal components to compensate for relative phases between the carriers in order to combine the carrier signals in phase.
65. The method of receiving CIMA communication signals recited in claim 64 wherein the step of providing (60mn) at least one set of predetermined delays to each set of received carrier-signal components is performed by a frequency-shifted feedback cavity.
66. The method of receiving CIMA communication signals recited in claim 62 wherein the step of combining (62m) the multi-frequency carrier-signal components in phase includes a multi-user detection step (66) in which interfering signals are weighted and combined with at least one intended user signal to cancel contributions of the multi-user interference to each intended user signal.
67. A method of communication between at least one transmitter and at least one receiver comprising generating (14n) a plurality of electromagnetic carrier signals, the carrier signals having a plurality of frequencies, and modulating (12) the carrier signals with at least one information signal, the method characterized by:
- phase offsetting (16n) each of the plurality of carrier signals wherein the phase offsets are incremental phase offsets, and
 - combining (24) the modulated, phase-offset carrier signals in at least one communication channel to generate interference between the modulated, phase-offset carrier signals for

providing at least one transmitted CIMA signal having a plurality of multi-frequency carrier-signal components.

receiving (52) the at least one transmitted CIMA signal from the at least one communication channel to produce a plurality of received multi-frequency carrier-signal components, the improvement comprising a step of combining (62m) the multi-frequency carrier-signal components in phase to generate at least one constructive-interference signal indicative of at least one information signal.

68. An electromagnetic-wave transmitter comprising a multicarrier generator (14n) capable of generating a plurality of electromagnetic carrier signals having a plurality of frequencies, and a carrier modulator (12) capable of modulating the carrier signals with at least one information signal, the improvement comprising:

a delay controller (16n) capable of applying a plurality of incremental phase offsets to the carrier signals for providing the carrier signals with a predetermined phase space at a predetermined time interval, and

an output coupler (24) capable of combining the modulated, phased carriers in at least one communication channel to produce at least one CIMA signal having a plurality of carrier-signal components.

69. The electromagnetic-wave transmitter claimed in Claim 68 wherein the output coupler (24) includes an array of transmitter elements.
70. The electromagnetic-wave transmitter claimed in Claim 69 wherein each transmitter element transmits a different carrier signal, thereby creating a time-dependent beam pattern.
71. The electromagnetic-wave transmitter claimed in Claim 69 wherein each transmitter element transmits a different carrier signal for each of a plurality of users, thereby creating a time-dependent beam pattern for each user.
72. The electromagnetic-wave transmitter claimed in Claim 71 further characterized by a multi-frequency controller for controlling the multicarrier generator (14n) to adjust frequency separation of the carriers, thereby controlling the scan rate of each beam pattern.

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73. The electromagnetic-wave transmitter claimed in Claim 68 wherein the output coupler (24) includes a coupler to a waveguide.
74. The electromagnetic-wave transmitter claimed in Claim 68 wherein the delay controller (16n) provides a plurality of incremental phase offsets to carrier signals that are uniformly separated in frequency.
75. The electromagnetic-wave transmitter claimed in Claim 68 wherein the delay controller (16n) provides a plurality of incremental phase offsets to carrier signals that are non-uniformly separated in frequency.
76. The electromagnetic-wave transmitter claimed in Claim 68 further characterized by an amplitude-control system (18n) for providing a tapered amplitude window to the carriers to reduce sidelobes.
77. The electromagnetic-wave transmitter claimed in Claim 68 wherein the carrier modulator (12) applies pulse-amplitude modulation to the carrier signals and the output coupler (24) combines the modulated, phased carriers in the at least one communication channel to produce at least one pulse-amplitude modulated CIMA signal.
78. The electromagnetic-wave transmitter claimed in Claim 77 wherein the output coupler (24) combines the modulated, phased carriers in the at least one communication channel to produce CIMA signals that occupy at least one nonzero phase space.
79. The electromagnetic-wave transmitter claimed in Claim 78 wherein the output coupler (24) combines the modulated, phased carriers in the at least one communication channel to produce CIMA signals that combine destructively in zero-phase space.
80. The electromagnetic-wave transmitter claimed in Claim 68 wherein the delay controller (16n) provides incremental phases to the carriers to match a chromatic dispersion profile of a waveguide for causing a predetermined phase relationship between the carriers to occur at a predetermined distance in the waveguide.

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81. The electromagnetic-wave transmitter claimed in Claim 68 wherein the delay controller (16n) provides a plurality of incremental phases to the carriers to generate a train of pulses, the transmitter further characterized by an amplitude-control system (18n) for providing a predetermined amplitude to each carrier signal to modulate a spread-spectrum code onto the pulse train.
82. An electromagnetic-wave receiver having a receiving element (52) capable of receiving transmitted signals from a communication channel for providing at least one set of received multi-frequency carrier-signal components, the improvement comprising:
a combiner (62mn) capable of combining the plurality of received multi-frequency carrier-signal components in phase to produce at least one constructive interference signal indicative of at least one information signal.
83. The electromagnetic-wave receiver claimed in Claim 82 wherein the receiver further comprises a phase-space delay compensator (60mn).
84. The electromagnetic-wave receiver claimed in Claim 83 wherein the phase-space delay compensator (60mn) is a frequency-shifted feedback cavity.
85. The electromagnetic-wave receiver claimed in Claim 83 wherein the phase-space delay compensator (60mn) samples within at least one predetermined time interval to detect at least one constructive interference signal in at least one zero-phase space.
86. The electromagnetic-wave receiver claimed in Claim 85 further comprising a signal estimator (66) that estimates the at least one information signal from a plurality of samples in a plurality of phase spaces.
87. The electromagnetic-wave receiver claimed in Claim 82 further comprising a signal estimator (66) that samples one or more interfering user signals that interfere with an intended user's signal, weights the sampled interfering signals, and combines the sampled interfering signals with the intended user's signal to cancel multi-user interference.

88. The electromagnetic-wave receiver claimed in Claim 82 wherein the combiner (62m) provides gain adjustment to at least one of the carrier-signal components to compensate for flat fading.
89. A carrier-interference multiple-access (CIMA) communication system comprising:
- an electromagnetic-wave transmitter comprising a multicarrier generator (14n) capable of generating a plurality of electromagnetic carrier signals having a plurality of frequencies, and a carrier modulator (12) capable of modulating the carrier signals with at least one information signal, the improvement comprising:
 - a delay controller (16n) capable of applying a plurality of incremental phase offsets to the carrier signals for providing the carrier signals with a predetermined phase space at a predetermined time interval, and
 - an output coupler (24) capable of combining the modulated, phased carriers in at least one communication channel to produce at least one CIMA signal having a plurality of carrier-signal components
 - an electromagnetic-wave receiver having a receiving element (52) capable of receiving transmitted signals from a communication channel for providing at least one set of received multi-frequency carrier-signal components, the improvement comprising:
 - a combiner (62mn) capable of combining the plurality of received multi-frequency carrier-signal components in phase to produce at least one constructive interference signal indicative of at least one information signal.
90. In a method for generating at least one spread-spectrum signal having at least one predetermined time-domain characteristic, the method comprising generating a plurality of carrier signals, the improvement comprising:
- phase offsetting (16n) the carrier signals to generate a predetermined time-domain profile for a superposition of the carrier signals,
 - providing (18n) a gain profile to the carrier signals to provide the at least one predetermined time-domain characteristic to the superposition of the carrier signals, and
 - combining (20) the modulated, phase-offset carrier signals to generate the superposition of the carrier signals having the at least one predetermined time-domain characteristic.

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